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Benefits of actions to reduce greenhouse gas emissions in Toronto

Prosperity and socio-economic equity

Prepared for the City of Toronto by the Pembina Institute

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This report was prepared for the Environment and Energy Division of the City of Toronto. It is one report in a series of studies exploring the benefits of greenhouse gas reduction actions in Toronto under the City's TransformTO strategy.

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Pembina Institute and Environment & Energy Division also consulted with a project Advisory Group who provided input to guide the development of the project. The Advisory Group included representatives from:

- Environment & Energy Division – Existing Buildings
- Environment & Energy Division – New Construction
- Environment & Energy Division – Policy and Research (Electric Vehicles)
- Environment & Energy Division – Policy and Research (Workforce Development)
- City Planning
- Economic Development & Culture
- Social Development, Finance & Administration – Tower and Neighbourhood Revitalization
- Transportation Services – Cycling Infrastructure & Programs
- Transportation Services – Pedestrian Projects
- The Atmospheric Fund

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Contents

List of Tables

Executive summary

The City of Toronto has an ambitious climate action strategy, *TransformTO,* to put the City on track to achieving its long-term target of reducing GHG emissions by 80% from 1990 levels by 2050 while ensuring a healthy, equitable and prosperous Toronto.

The City of Toronto recognizes that climate change is an economic, equity and quality of life issue and that taking action to mitigate climate change can generate significant benefits in health, social equity, economic prosperity and climate resilience. However, the ability to reliably understand and communicate these benefits is a leading challenge that cities face.

This report presents the results of a systematic search undertaken to compile, review and assess **existing methods (frameworks) and standard multipliers (coefficients)** used to quantify **economic** and **socio-economic equity benefits** of GHG-reduction actions, based on peer-reviewed academic literature and approaches used to quantify benefits in other jurisdictions. Subsequently, the report highlights the most relevant methods and multipliers for the City of Toronto context from among the options identified.

Across seven *TransformTO* climate action categories — building retrofits, green building standards, district energy system installations, decentralized renewable energy, electric vehicles public transportation infrastructure and investments, and active transportation infrastructure — we summarize the sources of economic and socio-economic benefits, as well as available methods and multipliers to quantify those benefits (summary table provided in Appendix B). In most categories, methods are available for quantifying economic output (GDP), job creation and energy cost savings associated with the climate action. We recommend the most relevant methods and multipliers available in the existing literature. To quantify socio-economic equity, we suggest, in most climate action categories, examining the distribution of climate action investments to equity-seeking and vulnerable groups and socio-economically disadvantaged neighbourhoods.

The relevant methods and multipliers should be interpreted and applied with caution to the City of Toronto context. For example, caution is required when applying multipliers derived from macroeconomic analysis to a specific project. Further, the literature review approach contains some inherent limitations related to matching the local conditions, time and duration of intervention, labour markets and other characteristics from studies to Toronto's climate plan.

The results of this work will help the City of Toronto understand and communicate the significant economic and socio-economic equity benefits that can potentially be obtained from climate action. Future work could include program measurement and modelling to refine the methods and multipliers for the City of Toronto as *TransformTO* implementation proceeds.

1. Purpose of report

The City of Toronto has an ambitious climate action strategy, *TransformTO,* to put the City on track to achieving its long-term target of reducing GHG emissions by 80% from 1990 levels by 2050 while ensuring a healthy, equitable and prosperous Toronto.

The City of Toronto recognizes that climate change is an economic, equity and quality of life issue and that taking action to mitigate climate change can generate significant benefits in health, social equity, economic prosperity and climate resilience. However, the ability to reliably understand and communicate these benefits to climate action, which are complex and interrelated, is a leading challenge that cities face.[1] Quantifying these benefits is an important step in reporting progress, measuring success, and guiding implementation to maximize such benefits.

There is currently no recognized standard for quantifying the benefits of GHG-reduction actions in cities. The City of Toronto is leading the way by undertaking work to develop a "made in Toronto" approach. As part of this effort, the Pembina Institute was retained by the City of Toronto to:

- Compile, review and assess **existing methods (frameworks) and standard multipliers (coefficients)** used to quantify **economic** and **socio-economic equity benefits** of GHG-reduction actions, based on peer-reviewed academic literature and approaches used to quantify benefits in other jurisdictions, and by international networks/organizations such as C40 Cities.
- Recommend and describe a **methods (frameworks) and standard multipliers (coefficients)** for Toronto to use to quantify **economic** and **socio-economic equity benefits** of GHG-reduction actions.

This report presents the findings from this work. We outline existing methods and multipliers associated with quantifying the benefits of seven climate action categories:

- building retrofits
- green building standards
- district energy system installations
- decentralized renewable energy
- electric vehicles

[1] C40 Cities, *Benefits of Climate Action: Piloting A Global Approach To Measurement: Final report* (2017). http://www.c40.org/researches/measuring-benefits

- public transportation infrastructure and investments
- active transportation infrastructure.

In Section 2, we provide an overview of the types of economic and socio-economic equity benefits that can accrue to cities and their residents when they take climate action. In Section 3, we discuss the methodology taken to complete this work, and the limitations related to that methodology. In Section 4, we present the findings from the main research effort — a systematic review of academic and grey literature to compile precedents. We also discuss the most relevant methods and multipliers for the City of Toronto context. In Section 5 we summarize the methods and multipliers that are retained.

While the shortlisted methods and multipliers are presented in Sections 4 and 5, the full list of identified methods and multipliers is presented in Appendix B.

2. Background: sources of economic and equity benefits

Over two-thirds of global greenhouse gas (GHG) emissions come from cities,[2] and urban residents will bear many of the costs of inaction on climate, such as extreme weather impacts. At the same time, cities are increasingly playing a pivotal leadership role in climate action, since they are uniquely placed to implement on-the-ground solutions.[3] Recognizing this opportunity and responsibility, the City of Toronto, via the *TransformTO* strategy, has established an ambitious action plan to mitigate climate change by transforming Toronto's urban systems across buildings, energy, transportation and waste. The City's goal is to achieve its long-term target of reducing emissions by 80% from 1990 levels by 2050 while ensuring a healthy, equitable and prosperous Toronto.

Three major categories of action are planned: already-approved climate actions in existing plans (e.g. Official Plan, Transit Network Plan, Ten Year Cycling Network Plan), short-term strategies and 2050 strategies identified in *TransformTO* Report #1 (November 2016), and acceleration actions identified in *TransformTO* Report #2 (April 2017).

Toronto is North America's fourth-largest city. Despite its strong economic growth, like other global cities Toronto is feeling the combined strains of rapid urbanization, growing inequality, complex weather conditions, and a transforming economy. The City of Toronto recognizes that climate change is an economic, equity and quality of life issue and that climate actions have significant potential to deliver on other city goals, including building a 21st-century economy and achieving greater socio-economic equity. One report commissioned by the city on the co-benefits of climate action concluded:

> *"…The co-benefits of an evidence-based climate action plan suggest that it could equally, and as successfully, be an economic development strategy, a healthy city plan, a competitiveness and innovation plan, a*

[2] *Benefits of Climate Action.*

[3] New Climate Institute and C40 Cities, *Opportunity 2030: Benefits of Climate Action in Cities* (2018). https://c40-production-images.s3.amazonaws.com/other_uploads/images/1668_C40_Opportunities_2030_report.original.pdf?1520440895

> *City fiscal management plan, an active transportation strategy, and an energy plan, all rolled up into one. With careful consideration, the climate action plan can also be a poverty alleviation strategy, and an inclusion strategy."*[4]

However, accurately measuring and articulating economic and socio-economic equity benefits is challenging, and depends on the collection of accurate and useful baseline and performance data. Further, climate action does not guarantee economic and socio-economic equity benefits; rather, intentional program design and collaboration with diverse communities is crucial to ensure the growth of the green economy and a fair distribution of benefits across society.[5] The present work will equip the City of Toronto to better measure and understand these interacting priorities, and ideally, help direct program design to maximize benefits and equity.

Economic benefits

Climate action can generate economic benefits in the following ways:

- Generating direct, indirect and induced jobs
- Lowering household and business energy demand, thereby saving costs, freeing disposable income for re-investment in the economy and improving business competitiveness
- Protecting households and businesses against energy price volatility
- Generating overall economic output (GDP) and associated tax revenue
- Mitigating future climate impacts that will be costly to society and reducing the cost of adaptation by acting early
- Improving public health, and therefore, productivity, through improved indoor and outdoor air quality, reduced noise, improved building comfort, etc.

The impacts of climate investments on job creation are highly dependent on local economic conditions.[6] If unemployment is relatively high, the potential for net job creation is larger compared to when the economy reaches full employment. The extent to which climate investments generate local jobs also depends on which economic

[4] Sustainability Solutions Group, *Modelling Toronto's Low Carbon Future – Technical Paper #4: Considerations of Co-benefits and Co-harms Associated with Low Carbon Actions for TransformTO* (2017), 2. http://taf.ca/wp-content/uploads/2017/02/170127_FINAL_Tech-Paper4_Cobenefits.pdf

[5] *Ibid.*

[6] Andrew Sudmant et al., *The Economics of Low Carbon Development: Calgary, Canada*, prepared for the City of Calgary (2018). http://www.calgary.ca/UEP/ESM/Documents/ESM-Documents/Economics-of-Low-Carbon-Development-Calgary.pdf

sectors are already present and whether concerted efforts are undertaken to develop skilled labour and local green economies where they do not yet exist. In the Toronto context, local job generation may be more difficult to quantify than in cities with more self-contained labour markets.

It is important to note that climate action can also generate economic costs, at least in the short term, by shifting demand from one product or service to another (e.g., from conventional fuels to electricity for vehicles). Therefore, studies of economic impact must take into account these disruptions and transitions by measuring *net growth*. By supporting the growth of new skilled labour, well-designed climate action also presents an opportunity to support the development of a future-ready workforce.

Quantifying job creation

Investment in climate action generates many different types of employment opportunities, through many different channels. In analyzing the jobs potential, three types of jobs are typically considered:

Direct jobs — on-site jobs that involve working directly on the project or at the facility. These include designers, developers, managers, construction workers and maintenance teams.

Indirect jobs — supporting services and goods needed for the direct jobs. These include activities along the supply chain such as manufacturing and third-party equipment procurement.

Induced jobs — jobs resulting from the spending of earnings or savings by those directly or indirectly employed or affected by the project. These include jobs at retailers, schools, hospitals and restaurants.

Unless otherwise specified, multipliers presented in this report are for direct, indirect and induced jobs combined.

Some studies express job potential in terms of total **job-years** over a period of time. This measure reflects the total amount of work created over time. For example, two full-time jobs that both last 10 years will be reported as 20 job-years. While total job-years indicate the total amount of work created, the **annual full-time equivalent (FTE)** reflects the amount of employment in any given year.

Further, the potential economic impact of climate action depends on when the action takes place. Research shows there is a strong economic case for switching to a lower-carbon development path in the short to medium term. Preparing to meet the challenges of long-term decarbonization sooner could significantly increase the chances of success, reduce the costs of mitigation over the long term, and ensure prosperous future cities.[7] Related to this, the order of climate action implementation matters: action in one area (e.g., greening the electricity grid) impacts the potential benefits in another (e.g., deploying electric mobility). Finally, economic and socio-economic benefits interact. For example, deployment of district energy systems can maintain affordability in housing over a longer term by avoiding equipment and long-term operating and maintenance costs, improving reliability, and by producing energy as a product for sale on the market.

Socio-economic equity

The City is committed to designing climate actions to maximize their benefit to equity-seeking and vulnerable groups by applying an equity lens to program design.[8] Populations with a lower socio-economic status face intersecting barriers and disadvantages related to energy use. For example, these populations tend to live in poorer-quality housing which costs more to heat or cool, and live in neighbourhoods with lower levels of transit accessibility and active transportation infrastructure, requiring either long commute times, or car ownership, to access work and other opportunities.[9,10] Therefore, climate action presents opportunities to develop a more equal and inclusive city by directing economic benefits to equity-seeking and vulnerable groups, including by:

- generating jobs or job training opportunities for groups with a lower socio-economic status (e.g., local hiring or training for climate-related infrastructure projects via Community Benefits Agreements, the City's Social Procurement Program, or workforce innovation initiatives[11])

[7] Ibid.

[8] City of Toronto, *TransformTO: Climate Action for a Healthy, Equitable and Prosperous Toronto*, Report #1. Staff Report no. PE15.1 (2016). https://www.toronto.ca/wp-content/uploads/2017/10/8ec4-TransformTO-Climate-Action-for-a-Healthy-Equitable-and-Prosperous-Toronto-Report-1-November-2016.pdf

[9] J. David Hulchanski, *The Three Cities Within Toronto: Income Polarization Among Toronto's Neighbourhoods, 1970-2005* (University of Toronto, 2010), 1. http://www.urbancentre.utoronto.ca/pdfs/curp/tnrn/Three-Cities-Within-Toronto-2010-Final.pdf

[10] Jeff Allen and Steven Farber, "Sizing up transport poverty: A national scale accounting of low-income households suffering from inaccessibility in Canada, and what to do about it," *Transport Poverty* 74, 2019.

[11] Toronto Workforce Innovation Group, *Constructing Toronto* (2015) http://workforceinnovation.ca/wp-content/uploads/2017/11/Contructing-Toronto_Final_V2.pdf

- ensuring that household cost savings and health benefits accrue to groups with a lower socio-economic status by directing climate investments toward participants in existing support programs (e.g., retrofitting social housing)
- recognizing that socio-economic conditions are not equally distributed in the City of Toronto,[12] and directing climate investments to geographic areas of the city that will benefit most (e.g., more disadvantaged or lower-income neighbourhoods).

Generally speaking, economic benefits are more easily monetized, measured and reported than equity benefits. Equity is a nuanced and complex concept with varying definitions, making it difficult to represent in a single numerical value or multiplier.[13] Because of this, equity is often unaccounted for in economic valuation studies of climate-related actions. To effectively capture the impacts of different policies or investments on equity, it is necessary to assess the distribution of costs and benefits.[14] Indeed, past work for TransformTO[15] has acknowledged the unique opportunity to spatially evaluate climate actions at the neighbourhood level. The majority of recommended equity benefit quantification methods in this report focus on the geographical distribution of investments and actions. For example, it is possible to study distribution of benefits at the neighbourhood level (using Wellbeing Toronto indicators),[16] at the census tract level, or specifically for Neighbourhood Improvement Areas identified in the Toronto Strong Neighbourhoods Strategy.

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[12] David J. Hulchanski, *The Three Cities Within Toronto: Income Polarization Among Toronto's Neighbourhoods, 1970-2005* (University of Toronto, 2007). http://www.urbancentre.utoronto.ca/pdfs/curp/tnrn/Three-Cities-Within-Toronto-2010-Final.pdf

[13] Kevin Manaugh, Madhav Badami, and Ahmed El-Geneidy, "Integrating social equity into urban transportation planning: A critical evaluation of equity objectives and measures in transportation plans in North America," *Transport Policy* 37 (2015), 167-176. doi:10.1016/j.tranpol.2014.09.013

[14] Karen Lucas, Bert van Wee, and Kees Maat, "A method to evaluate equitable accessibility: combiningethical theories and accessibility-based approaches," *Transportation* 43 (2016), 473-490. doi:10.1007/s11116-015-9585-2

[15] *Modelling Toronto's Low Carbon Future – Technical Report #4*, 2.

[16] City of Toronto, "About Wellbeing Toronto." https://www.toronto.ca/city-government/data-research-maps/neighbourhoods-communities/wellbeing-toronto/about-wellbeing-toronto/

Equity, the City of Toronto, and climate change

The City of Toronto defines **equity-seeking groups** as: persons with disabilities; women, racialized group(s); lesbian, gay, bisexual, trans, queer, two-spirit (LGBTQ2S) communities; undocumented workers; immigrants and refugees; persons with low income; and youth. The City further defines **vulnerable populations** as seniors, victims of violence, persons with low literacy, persons who are homeless or under-housed, residents in Neighbourhood Improvement Areas. The City also recognizes the unique status and cultural diversity of Indigenous communities and their right to self-determination.[17]

Many members of the above groups have a lower socio-economic status due to historical and present-day discrimination and disadvantage. It is important to note that climate change impacts, such as extreme weather, will take the greatest toll these groups—in the global south and north—but through transformative policies, governments could address the root causes of inequalities.[18]

Other initiatives

The City of Toronto is not the only Canadian city working to better understand, quantify and communicate benefits of climate action. A recent study commissioned by the City of Calgary from a consortium of research institutions provides an interesting example of custom modelling of benefits.[19] The City of Edmonton has also undertaken research and engagement to develop a portrait of local green economies, which will set the stage for supporting growth in these industries with climate action.[20] The City of Toronto can benefit by harnessing the lessons learned from these initiatives, and has an opportunity to share the results of its current process with other cities.

[17] City of Toronto, "Equity, Diversity and Inclusion within the City of Toronto," 2018. https://www.toronto.ca/city-government/council/2018-council-issue-notes/torontos-equity/equity-diversity-and-inclusion-within-the-city-of-toronto/

[18] United Nations, "Report: Inequalities exacerbate climate impacts on poor," media release, October 3, 2016. https://www.un.org/sustainabledevelopment/blog/2016/10/report-inequalities-exacerbate-climate-impacts-on-poor/

[19] *The Economics of Low Carbon Development.*

[20] Delphi Group, *Edmonton's Green Energy Economy: Summary Report* (2018). http://www.edmontonindustrial.ca/documents/Edmonton_Green_Energy_Economy_Report_Web_Version_2018.pdf

3. Methodology

Key terms

In this report, we use the following terms:

A **base unit** describes a specific climate action undertaken with a numerical value. For example, building energy retrofit programs may be described by the dollars invested in the program. We have made efforts in the research to match the proposed base units to program data already collected by the City of Toronto.

A **multiplier** (coefficient) is the value by which the base unit can be multiplied to obtain a numerical value that describes the benefit of the climate action. In other words, a multiplier is the ratio of the total benefits to the initial inputs (base units). In this report, multipliers are derived from the literature and selected for their applicability to the City of Toronto.

The **method** (framework) is the term used to describe the approach used here to quantify the benefit; in other words:

Base unit x Multiplier = Benefit

The literature review employed a systematic approach in selecting documents and collecting data. In November 2018, consistent queries were input into Google Search and Google Scholar following this structure:

[category of climate action] AND (econ* mutlipl* OR econ* equit*) AND [geography]

with "[category of climate action]" denoting one of the seven climate action categories and "[geography]" denoting jurisdictions where findings transferable to the City of Toronto could be expected, e.g., Canada, the United States, the European Union, and locations within these jurisdictions. From that foundation, additional documents were selected from in-text citations, literature provided by City of Toronto staff, and further desktop research to fill gaps. Researchers scanned all documents for two types of information: (1) generalizable descriptions of how climate action initiatives impact the economy, directly and indirectly, and (2) explicit methods and multipliers quantifying the economic and socio-economic impacts of climate actions.

3.1 Limitations

The scope of this research and analysis is limited to methods and multipliers available from a literature review. While it would also be possible to develop locally relevant multipliers through modelling or secondary research (e.g. expert interviews), these activities were not in scope. As such, several limitations should be considered when interpreting the findings:

- The scope of socio-economic impacts varies among studies. While not an issue when examining a single study, it precludes the averaging of multipliers. Where necessary, we prioritized conservative multipliers or provided a range of acceptable multipliers.
- Purchasing power parity varies considerably among studies, meaning that labour, capital, and financing costs may differ from those in other jurisdictions. We prioritize data from large Canadian, U.S., and European jurisdictions economically similar to Toronto. Studies published within the past five years took priority.
- Climate actions are highly interrelated, but relationships among sectors are not always addressed within the literature. We take a conservative view of interlinkages wherever applicable, e.g., not assuming electric vehicles in Toronto primarily impact the Ontario automotive industry.
- Many studies quantify climate action benefit at a national or provincial/state scale, but rarely at the municipal scale. It is necessary then to exercise caution when translating multipliers developed for national economies to the local context. In particular, applying multipliers derived from large-scale investment programs to an individual project could have a high degree of error even if the multiplier is generally appropriate for the city context.
- The benefits of climate action are highly dependent on the timing and duration of investments. The element of time is difficult to account for when developing universal methods and multipliers.

3.2 Determining most relevant multipliers for the City of Toronto

Because of these limitations, methods and multipliers derived from the literature, especially from other jurisdictions, should be applied and interpreted with caution in the Toronto context.

In addition to the approaches used to mitigate the limitations of the literature described above, the following considerations were applied when recommending the most relevant multipliers for the City of Toronto from the literature:

Applicable base units

The City of Toronto provided information on the baseline data that is already collected by the City across climate action areas, upon which to apply the methods and multipliers to determine benefit (Appendix 1). Where possible when reviewing existing literature, efforts were made to prioritize methods and multipliers that can be applied to the City's existing base units.

Relevant geographies

We excluded jurisdictions with energy and urban systems that are not comparable to Toronto (e.g. global South, different climate). Within the longlisted multipliers, we chose findings from Canada, Ontario or Toronto wherever possible. It is important to note that several studies conducted in the Ontario context had been done with the assumption that the former Ontario Climate Change Action Plan would be implemented and the Green Energy Act would be in place; however, those programs have now been cancelled.

Match to TransformTO

We prioritized methods and multipliers that apply to the specific committed actions under TransformTO.

While our review prioritizes conservative estimates recently drawn from jurisdictions whose economic characteristics resemble those of the City of Toronto, there is no replacement for modelling based on local conditions, and program measurement as the actions are implemented over time.

4. Findings

In the following sections we present the research findings for each of the seven action categories, illustrating the economic and socio-economic equity benefit methods and multipliers in the studies we reviewed. We highlight most relevant methods and multipliers from the literature for the Toronto context and propose approaches to measure the distribution of benefits from a socio-economic equity perspective.

A long list of possible methods and multipliers derived from the literature review is provided in Appendix B.

Buildings

4.1 Building retrofits

Building retrofits improve the energy efficiency of the existing building stock through structural repairs, renovations, and new heavy appliances. Retrofit activities can include window and door replacements, wall insulation and air sealing, or installing high-efficiency water heaters and heating/cooling systems,[21] and can be applied to all types of buildings (single- or multi-family dwellings, commercial and industrial buildings). Most of the City of Toronto's retrofit programs take the form of loans rather than grants.

TransformTO measures

Short-term strategies

- Enhance the Better Buildings Partnership (BBP) to accelerate retrofits of commercial and institutional buildings.
- Establish innovative financing mechanisms to channel new money into TransformTO strategies supporting the development and implementation of energy retrofit projects in the commercial, multi-unit residential buildings (MURB), and residential sectors.

[21] Natural Resources Canada, "Retrofitting," May 5, 2018. https://www.nrcan.gc.ca/energy/efficiency/buildings/20707

- Improve energy efficiency of social housing by retrofitting up to 40% of social housing building stock (Toronto Community Housing Corporation (TCHC) housing).
- Continue support for residential property owners by retrofitting residential buildings at a scaled-up rate (HELP, Hi-RIS, or similar programs).

2050 strategies

- Aggressive retrofits of existing buildings by scaling existing programs including the BBP, HELP and Hi-RIS
- Exploring regulation for existing building energy performance

Types of benefits

Investing in building retrofits offers great potential to stimulate economic growth. Possible economic benefits include:

- Direct job creation (unskilled, skilled, and professional jobs)[22] in industries such as building audits, retrofit installation, and administration; and indirect job creation from upstream and downstream jobs, for example in logistics, appliance and building materials manufacturing
- Induced benefits from energy cost savings accruing to homeowners or building owners:
  - Retrofits can save owners and occupants 10-60% on annual household energy.[23]
  - Energy efficiency retrofits can in particular reduce the high cost burden of energy on lower-income households if they are able to access and monetize the benefits of retrofits.[24]
- Growth in GDP from the growth of the green economy and reinvestment of savings in other activities
- Increased productivity and improved health from higher-quality housing and workplaces (e.g., from improved indoor air quality and comfort).

[22] *Opportunity 2030.*

[23] Ibid.

[24] Ariel Drehobl and Lauren Ross, *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities* (American Council for an Energy-Efficient Economy, 2016), 6.
http://energyefficiencyforall.org/sites/default/files/Lifting%20the%20High%20Energy%20Burden_0.pdf

Most relevant methods and multipliers in the literature

In the literature on retrofits, methods and multipliers that link benefits to the dollars invested are common. Few studies were available that linked benefits to floor area or building value rather than investments.

The literature shows that the multiplier applicable to retrofits is particularly dependent on the extent of action and the choice of base unit. Furthermore, the multiplier depends on whether government spending only, or combined government and private sector spending, is used in the calculation. Because the multiplier is a ratio of benefit to spending, if the multiplier is developed to apply to government spending only (a lower figure compared to combined spending), the multiplier will be higher. Conversely, where the benefit is linked to total spending (including the private sector) for the same action, the multiplier will be lower (a higher figure compared to government spending only). Finally, and as a separate issue, the literature tends to show somewhat lower economic benefits for commercial retrofits compared to residential.

Several macroeconomic studies have quantified the benefits of national or sub-national spending on energy efficiency measures, including but not limited to building retrofits. For example, a study by Dunsky Energy Consulting[25] modelled committed actions in the 2016 Pan-Canadian Framework on Clean Growth and Climate Change, including energy efficiency retrofits to existing housing, improvements to model codes as new codes become "net-zero ready," stringent energy efficiency standards for appliances and equipment, and energy management and emissions standards for large industry. This study found that PCF measures are expected to result in 16-30 job-years[26] per $1 million in government spending and $4-7 net GDP growth per $1 in government spending over the program timeline (2017-2030). The lower multipliers are for the more-ambitious energy efficiency scenarios (PCF plus a suite of other measures in line with leading jurisdictions in North America), while the higher multipliers are for the PCF package as written. While they give a sense of scale, these multipliers are not considered sufficiently relevant for the Toronto context because they are linked to government spending only (as opposed to private sector spending), and because the study modelled actions other than building retrofits.

[25] Dunsky Energy Consulting, *The Economic Impact of Improved Energy Efficiency in Canada*, (2018). http://cleanenergycanada.org/wp-content/uploads/2018/04/TechnicalReport_EnergyEfficiency_20180403_FINAL.pdf

[26] A job-year represents the equivalent of one full-time position for a period of one year.

A study by the Acadia Center[27] modelled electric, natural gas and liquid fossil fuel efficiency programs in the residential and commercial–industrial market segments for a range of hypothetical levels of effort. For Ontario, this study found that efficiency measures are expected to result in 17-21 job-years per $1 million in total spending, and $2.40-3.00 in net GDP growth per $1 in total spending over the program timeline (2012-2040). Again, the lower multiplier corresponds to a higher energy efficiency scenario. These multipliers are based on modelling for the province of Ontario specifically and incorporate government and private sector spending, so are considered more relevant for the Toronto context.

A similar study for the U.S. by the Institute for Market Transformation[28] found somewhat lower job multipliers for energy efficiency measures: 13.41 net jobs per $1 million investment on multifamily buildings and 12.94 jobs per $1 million investment on commercial buildings. In Calgary, a study prepared for the City[29] predicted 13.1 job-years per $1 million investment for residential buildings and 8.7 job-years per $1 million investment for commercial buildings.

Some case studies[30] have quantified annual energy cost savings accruing to households from retrofits. When energy cost savings are channelled to other non-energy spending, additional jobs are created. The U.S. study referenced above estimated that an additional 5.32 net jobs are created for every $1 million in energy cost savings for multifamily and commercial buildings.

Possible approaches to quantifying socio-economic equity

Social and affordable housing is regarded as an important sector to mobilize retrofits. There are opportunities to work directly with social and affordable housing

[27] Acadia Center, *Energy Efficiency: Engine of Economic Growth in Canada* (2014). https://acadiacenter.org/document/energy-efficiency-engine-of-economic-growth-in-canada/

[28] Andrew Burr, Cliff Majersik, Sarah Stellberg, and Heidi Garrett-Peltier, *Analysis of Job Creation and Energy Cost Savings from Building Energy Rating and Disclosure Policy* (Institute for Market Transformation, 2012). https://www.imt.org/resources/analysis-of-job-creation-and-energy-cost-savings-from-building-energy-ratin/

[29] *The Economics of Low Carbon Development.*

[30] C40 Cities, Sustainia & Realdania, *Cities 100: 100 solutions for climate action in cities* (2017). https://www.realdania.org/-/media/Realdaniadk/Nyheder/2017/Cities100/Cities100_17_WEB_ok.pdf?la=en

organizations, institutional actors who can share lessons learned and undertake retrofits at scale.[31]

Low-income households, many of whom live in social or market affordable housing, stand to benefit significantly from improved housing quality and energy cost savings.[32] However, structural barriers currently exist in Toronto. For example, savings do not accrue to occupants of social housing or rental housing where occupants do not pay their hydro bills. Where occupants do pay, there is little or no incentive for the building owner to undertake a retrofit. The extent to which there are equity benefits from retrofits therefore depends on program design.

With this challenge in mind, a starting point for quantifying socio-economic equity benefits from building retrofits in Toronto is nonetheless to measure the number of social and affordable housing units (e.g., TCHC units) that have undergone retrofits. The City could also measure the distribution of City-supported retrofit projects according to neighbourhood (using Wellbeing Toronto indicators to measure socio-economic status), census tract, or NIA and compare socio-economically disadvantaged areas to the whole.

The methods and multipliers identified in the literature for building retrofits are presented in the Appendix in Table 3. A selection of the most relevant methods and multipliers to the City of Toronto is presented in Table 1, Section 5 (Summary).

4.2 Green building standards

Green building standards set energy efficiency standards for the design, construction, operation and maintenance of buildings over and above what is required by the Ontario Building Code. The Toronto Green Standard consists of tiers of performance measures with supporting guidelines that promote sustainable site and building design. Tier 1 of the Toronto Green Standard is required through the planning approval process. Tiers 2

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[31] Evergreen, *Review of Effectiveness of Investments in Renewable Energy for Social and Affordable Housing* (2017). https://sustainabletechnologies.ca/app/uploads/2016/10/Full-Final-Report-for-publication-08012017.pdf

[32] Peter Harrison, *Home Energy Spending in Ontario: Regional and Income Distribution Perspectives* (Financial Accountability Office of Ontario, 2016), https://www.fao-on.org/web/default/files/commentaries/1618%20home%20energy%20regional/Home%20Energy%20Spending%20Regional.pdf

to 4 are higher level voluntary standards associated with financial incentives and verified post construction.

The City of Toronto's Zero Emissions Buildings Framework,[33] adopted by Council in December 2017, sets out performance targets for each of five different building types and was an update to the Toronto Green Standard (TGS), initially established in 2010. The new performance targets are designed to take the building industry from today's building practices to a near-zero emissions level of performance by the year 2030; they emphasize measurement of total energy use, thermal demand reduction and greenhouse gas intensity. Version 3 of the TGS is in effect for all new planning applications as of May 2018.

TransformTO measures

Short-term strategies

- Advance a leading-edge new construction standard by undertaking the necessary research to support integration into the TGS of more progressive energy efficiency requirements (see above).

2050 strategies

- Ongoing updates to the TGS, including exploring adopting a long-term zero emissions target (see above).

Types of benefits

The benefits of more stringent building standards are similar to those for building retrofits. Protecting households and businesses against energy price volatility is a particular benefit, including for social housing. Furthermore, better-performing buildings are in increasingly high demand by corporate, public and individual buyers and tenants, which can lead to higher building and assessment values, rents and sales prices.[34, 35]

[33] City of Toronto and The Atmospheric Fund, The City of Toronto Zero Emissions Buildings Framework (2017). https://www.toronto.ca/wp-content/uploads/2017/11/9875-Zero-Emissions-Buildings-Framework-Report.pdf

[34] McGraw Hill Construction, *World Green Buildings Study* (2012). Available at http://analyticsstore.construction.com/index.php/2012-world-green-building-trends-key-facts.html

[35] T. Kesik and A. Miller, *Toronto Green Development Standard Cost-Benefit Study* (2008). http://www.daniels.utoronto.ca/sites/daniels.utoronto.ca/files/old/Kesik_TGDS_CB-Study_Oct2008.pdf

Most relevant methods and multipliers in the literature

There are few studies demonstrating the added economic benefits of green building standards compared to status quo construction. There is also a challenge in cross-applying multipliers as standards and rating systems in other jurisdictions have different requirements. Similar to retrofits of existing buildings, available methods and multipliers for new building standards, where they exist, are often linked to investment levels, rather than floor area or building value.

For the United States, an analysis conducted for the U.S. Green Building Council[36] found that new residential permanent site single- and multi-family structures yielded 17.1 job-years per $1 million in investment, while new commercial and healthcare buildings yielded 19.2 job-years per $1 million in investment, for green building construction from 2000 to 2013 estimates. A green building was defined in this study as a building built to LEED standards (or an equivalent green building certification program), or one that incorporates numerous green building elements across five category areas: energy efficiency, water efficiency, resource efficiency, responsible site management and improved indoor air quality. The study also estimated economic benefits from the LEED certification program specifically, but did not calibrate the benefits to investment dollars to make the findings transferrable. No comparable studies specific to the Canadian context were found in the literature, so these multipliers are considered most relevant for Toronto. It is of note that they are comparable to the job multipliers for building retrofits.

An important financial benefit of green buildings comes from their increased attractiveness to renters and buyers. McGraw-Hill Construction and the Canadian Green Building Council[37] surveyed building owners and reported that green buildings (defined in this study as a construction project that is either certified under any recognized global green rating system or built to qualify for certification) are estimated to be valued 4% higher than comparable buildings without a green status in Canada. This same study also reported estimated operating cost savings to green building owners of 8% over one year and 11% over five years. While these multipliers should be applied with some caution because they were developed from owner surveys rather than measurement,

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[36] U.S. Green Building Council, *Green Jobs Study*, prepared by Booz Allen Hamilton (2012). https://www.iccsafe.org/gr/Documents/GreenToolkit/GreenJobs-USGBC.pdf

[37] McGraw-Hill Construction and CaGBC, *Canada Green Building Trends Report*, 7. https://www.cagbc.org/cagbcdocs/resources/CaGBC%20McGraw%20Hill%20Cdn%20Market%20Study.pdf

they could be validated against City of Toronto data for those buildings constructed under Tier 1 and Tier 2 TGS.

Finally, a recent cost-benefit analysis conducted by Sustainable Buildings Canada[38] for The Atmospheric Fund determined the net present value of a number of building standard improvement options with a view to updating the TGS. This study gives access to other financial indicators related to specific types of efficiency improvements; however, net present value results, a financial indicator, are not easily translated into economic multipliers.

Possible approaches to quantifying socio-economic equity

Since newer buildings tend to be occupied by less-disadvantaged groups,[39] the opportunity for efficient new buildings to bring socio-economic equity benefit is somewhat lower compared to retrofits, except when programs target social and affordable housing units. Tier 1 of the TGS could apply to new TCHC buildings.

No specific socio-economic equity indicators for the TGS are proposed at this time.

The methods and multipliers identified in the literature for green building standards are presented in the Appendix in Table 2. A selection of the most relevant methods and multipliers to the City of Toronto is presented in Table 1, Section 5 (Summary).

Energy Systems

4.3 District energy systems

District energy systems (DES), sometimes called low-carbon thermal energy networks, distribute heat and cooling from a central location across multiple buildings, and allow sharing of thermal energy between buildings through an efficient system of pipes. This uses energy sources more efficiently and allows energy demand to be managed at an aggregate level. District energy systems often take advantage of renewable energy

[38] Sustainable Buildings Canada, *Cost/Benefit Analysis of Proposed Energy Efficiency Requirements for the Toronto Green Standard: Final Report* (2012). http://taf.ca/publications/toronto-green-standard-cost-benefit-analysis/

[39] Cherise Burda, Graham Haines and Shaun Hildebrand, *Bedrooms in the Sky: Is Toronto Building the Right Condo Supply* (Ryerson City Building Institute, 2017), 2. https://www.citybuildinginstitute.ca/wp-content/uploads/2017/11/FINAL-BedroomsInTheSky.pdf

sources and allow buildings to shift away from more carbon-intensive heating and cooling fuels and technologies, as low-carbon technologies become available.

District energy is not new to the Toronto region. The University of Toronto's system has been operating since 1912 and York University's Keele Campus system since the 1960s. Many buildings in downtown Toronto are connected to a deep lake water cooling system and a new DES was recently installed in Regent Park.[40] There is significant opportunity for DES in Toronto because of the pace of urban development and the high demand for heating and cooling throughout the year, but these systems require early entry in the urban planning process to be realized.

DES can also produce energy when paired with combined heat and power (CHP) systems. CHP utilizes a single source of fuel for electrical power generation and recovery of waste heat, and can achieve high combined efficiencies[41] and opportunities for additional revenue generation.

TransformTO measures

Short-term strategies

- Advance low-carbon/renewable thermal energy networks by reducing emissions from existing district energy systems by 3% to 30% by 2020.

2050 strategies

- Shifting away from natural gas for thermal heating requirements of buildings to lower-carbon alternatives.

Types of benefits

Economic benefits from DES typically include:[42,43,44]

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[40] City of Toronto, "District Energy." https://www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/district-energy/

[41] FVB Energy, *Integrated Community Energy System Feasibility Study*, prepared for City of Burlington (2016). https://www.burlington.ca/en/live-and-play/resources/Environment/Energy/CW-01-16-Appendix-A-Integrated-Community-Energy-Feasibility-Study.pdf

[42] Farallon Consultants Limited, *Feasibility Study for a District Energy System: City of Courtenay*, prepared for City of Courtenay (2013). https://www.courtenay.ca/assets/Community/Environment/city of courtenay des feasibility study final 2013 02 21.pdf

[43] *Integrated Community Energy System Feasibility Study.*

[44] U.N. Environment Programme, *District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy* (2015). https://wedocs.unep.org/bitstream/handle/20.500.11822/9317/-District_energy_in_cities_unlocking_the_potential_of_energy_efficiency_and_renewable_ene.pdf

- Job creation from the local construction and operation of DES
- Reduced dependency on conventional fuels produced in other jurisdictions
- Reduced life cycle costs for building owners and avoided costs to purchase, maintain and replace conventional heating and cooling systems
  - This includes simplified building operations, reduced size of mechanical rooms, reduced water and chemicals usage, etc.
- Price stability to building owners from predictable multi-year energy contracts
- Reduced energy volatility system-wide as a result of decentralized production
- Attracting premium employment to DES-served areas and associated high-quality jobs[45]
- Possible revenue generation for municipalities or other DES owners
- Increased energy security from resilience to electrical grid shocks and built-in redundancy and flexibility, possible lower insurance premiums, and potential for long term least cost energy supploy since the district system is able to switch to the lowest cost energy source
  - Such resilience benefits, in the form of greater protection from health and safety impacts during emergencies, can be particularly important to more vulnerable groups
- Through CHP technologies, the addition of new locally-generated electricity into a locally-constrained grid.

Most relevant methods and multipliers in the literature

Each DES is unique in its size, location, energy source, ownership model and whether or not electricity is cogenerated. As a result, it is difficult to obtain transferrable methods and multipliers for quantifying benefits from the literature and it may be preferable to evaluate benefits on a project-by-project basis. To this end, Natural Resources Canada has created the District Energy Economic Model (DEEM), which uses detailed cost estimates and statistical economic multipliers to estimate the direct and indirect socio-economic impact of DES within Canada over project lifetimes.[46] This tool can be used to estimate job creation and local revenue from specific DES projects.

The DEEM tool was used to evaluate Markham District Energy, a municipally owned thermal energy utility in neighbouring Markham, Ontario. The system was found to yield $1.37 in additional economic activity (GDP) for every $1 in investment between

[45] *Integrated Community Energy System Feasibility Study.*

[46] ReNew Canada, "Measuring the Impact," August 28, 2015. https://www.renewcanada.net/feature/measuring-the-impact/

2000 and 2010.[47] This is the most readily available multiplier for the Toronto context; however, as noted above, it may not be directly applicable to other DES projects.

Several studies have illustrated the benefits of DES, particularly in European cities, in terms of job and new business creation in cities like Rotterdam (Netherlands),[48] Güssing (Austria),[49] and Oslo (Norway).[50] However, these studies in different jurisdictions are not considered sufficient to generate a reliable multiplier for Toronto.

Possible approaches to quantifying socio-economic equity

Socio-economic benefits from DES accrue from reduced household energy demand. As in other areas of climate action, lower-income households can have the greatest marginal benefits from savings on energy costs,[51] where they have access to such systems. Benefits from DES also include thermal energy security (the ability to provide heating and cooling even during an emergency or storm) and reduced energy price volatility. Price volatility can be a particular challenge for vulnerable groups.

There is a significant opportunity to pair DES deployment with social and affordable housing development. For example, the TCHC seized the opportunity of revitalizing the Regent Park community to install a DES. Along with market condominium units, the community will be home to over 2,000 rent-geared-to-income units and nearly 500 new affordable rental units.[52] All of these units will benefit from sourcing their energy, and eventually electricity, from the DES and combined heat and power system. One option to measure socio-economic equity benefits associated with DES, therefore, is to measure the number of social and affordable housing units connected to DES over time.

The methods and multipliers identified in the literature for district energy system installations are presented in the Appendix in Table 5. A selection of the most relevant methods and multipliers to the City of Toronto is presented in Table 1, Section 5 (Summary).

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[47] Markham District Energy, "District Energy in Cities," March 10, 2015. http://www.markhamdistrictenergy.com/district-energy-in-cities/

[48] *Cities 100.*

[49] *District Energy in Cities, 29.*

[50] Ibid.

[51] *District Energy in Cities.*

[52] Toronto Community Housing, "Regent Park." https://www.torontohousing.ca/regentpark

4.4 Decentralized renewable energy

Decentralized renewable energy refers to small-scale investments in renewable energy (solar photovoltaic (PV), wind, geothermal) on homes, commercial buildings, etc. Toronto programs have an emphasis on solar PV initiatives, including a mandate to install renewable energy systems on all city buildings by 2020 and decentralized energy incentives tied to building retrofit programs noted above.[53]

TransformTO measures

Short-term strategies

- Create a renewable energy strategy to advance emerging clean technologies such as solar PV, wind, biogas, geo exchange and energy storage.

Types of benefits

Benefits from distributed renewable energy deployment include:

- Job creation in the renewable energy sector for project developers, manufacturers, engineering consultants and related service providers
- Increased property values and energy cost savings for building owners and occupants
  - Lower-income populations could obtain the greatest marginal benefit from energy cost savings, but as with building retrofits, there are structural barriers to accessing these opportunities.

Canada's solar electricity sector is growing rapidly. Much of this success is based on the growth of the Ontario solar market where more than 99% of Canada's solar electricity is generated; Ontario has developed a globally recognized solar market sector.[54] While most solar panels are manufactured in China, Ontario does have some component manufacturing activity.[55] However, the other aspects of the supply chain (development, professional services, construction, and operations and maintenance) are much more

[53] City of Toronto, "Renewable Energy Policy for City Buildings," 2018. https://www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/greening-city-operations/renewable-energy/

[54] CanSIA, *Roadmap 2020: Powering Canada's Future With Solar Electricity* (2015). https://www.cansia.ca/uploads/7/2/5/1/72513707/cansia_roadmap_2020_final.pdf

[55] CanSIA and CanmetEnergy, *National Survey Report of PV Power Applications in Canada* (2012). http://www.iea-pvps.org/index.php?id=93&no_cache=1&tx_damfrontend_pi1%5BshowUid%5D=740&tx_damfrontend_pi1%5BbackPid%5D=93

developed in the province.[56] A 2017 market analysis of Ontario's renewable energy sector found that solar PV represents the highest proportion of the employment impacts compared to other sources of renewable energy over the forecast period due to its relatively higher employment intensity on a per-megawatt basis.[57]

Most relevant methods and multipliers in the literature

Whereas building efficiency multipliers tend to be linked to dollars invested, multipliers for renewable energy deployment tend to be linked to the power output (megawatts) of the energy systems deployed. The literature shows that residential solar is more labour-intensive than utility-scale solar because it is relatively more work to build the same amount of PV in a rooftop setting.

Recent Ontario-based studies are available that model economic benefits from solar PV deployment. Based on contracts and commitments, forecast attrition, and forecast net metering adoption as of 2017, the Ontario Ministry of Energy[58] estimated that each megawatt of residential solar deployed in the province would bring GDP growth of $900,000 and create 20.9 job-years. This multiplier is considered more relevant for the Toronto context because it is Ontario-based and scoped to residential solar PV, which is the focus of *TransformTO*. Other studies, such as the CanSIA Roadmap 2020,[59] obtained lower job multipliers (10.3 job-years per megawatt) when including utility-scale solar or focusing only on direct jobs in construction and installation.

Possible approaches to quantifying socio-economic equity

As with building retrofits, there are opportunities to work directly with social and affordable housing organizations to deploy distributed renewable energy. Low-income households, many of whom live in social and affordable housing, stand to benefit significantly from energy cost savings and reliability, but savings do not accrue to occupants of social housing or rental housing where those occupants do not have access

[56] Ontario Ministry of Energy, *Market Analysis of Ontario's Renewable Energy Sector* (2017). https://www.ontarioenergyreport.ca/pdfs/COMPLETE%20FINAL_MOE%20Ontario%20Market%20Assessment_July%2020,%202017.pdf

[57] Ibid.

[58] Ibid.

[59] CanSIA, *The Role of Solar in Ontario's Climate Action Plan* (2016). https://www.cansia.ca/uploads/7/2/5/1/72513707/the_role_of_solar_in_ontarios_climate_action_plan_vf_20160308.pdf

to the meter. The extent to which there are equity benefits therefore depends on program design.

A Toronto-based study conducted by the Toronto and Region Conservation Authority[60] explored the benefits generated from efforts to deploy renewable energy on social and affordable housing in Toronto. When including returns from the now-ended provincial Feed-In Tariff program, the study found that each dollar of investment in renewables generated $1.60 in net benefits to housing providers. Because this incentive program is no longer available, this multiplier is not considered relevant for the Toronto context currently. However, the City could measure the megawatts deployed to social housing (e.g., TCHC buildings). Alternatively, it could measure deployment according to neighbourhood (using Wellbeing Toronto indicators to measure socio-economic status), census tract, or NIA and compare socio-economically disadvantaged areas to the whole City.

The methods and multipliers identified in the literature for decentralized renewable energy are presented in the Appendix in Table 4. A selection of the most relevant methods and multipliers to the City of Toronto is presented in Table 1, Section 5 (Summary).

Transportation

4.5 Electric vehicles

Electric vehicles (EVs) are growing rapidly in market presence. Cities can take action to support EV uptake among their residents.

TransformTO measures

Short-term strategies

- Enable electric vehicles (EVs) by supporting Toronto in accelerating electric vehicle sales by 2020.

[60] Toronto and Region Conservation Authority, *Review of Effectiveness of Investments in Renewable Energy for Social And Affordable Housing*. prepared for Evergreen (2017). https://sustainabletechnologies.ca/app/uploads/2016/10/Full-Final-Report-for-publication-08012017.pdf

- City of Toronto investments prioritize on-street charging infrastructure, which has been distributed through ward-level pilot projects.[61]

2050 strategies

- Work with the Province to support the anticipated adoption of EVs by developing policies and programs to expand EV use in Toronto, particularly with respect to vehicle charging stations and parking.
- Partner with Toronto Hydro to provide needed infrastructure and electrical grid resilience.

Types of benefits

The benefits from increased EV uptake include:

- Fuel and maintenance cost savings to vehicle owners (this is considered one of the primary economic benefits from increased EV uptake[62])
- Reduced reliance on conventional fuels produced in other jurisdictions
- Job creation from manufacturing, operations and maintenance, and infrastructure (charger) deployment
- Reductions in traffic-related air pollution and noise, and resulting benefits to public health and productivity.

EV uptake is expanding globally: by some estimates, EVs will make up 54% of new global car sales by 2040.[63] When estimating job creation from EV uptake it is important to consider the distribution of EV and EV charging station infrastructure manufacturing across North America. City of Toronto efforts to increase EV uptake would not necessarily result in the growth of a new EV manufacturing industry in Ontario without supportive provincial and federal policy, other investments and actions by other players. Indeed, a study commissioned by the City of Calgary[64] assumed a net zero impact on employment for city actions to increase EV uptake. There are, however, more certain opportunities to create jobs through the operation and maintenance of EVs and the manufacture and buildout of charging infrastructure. Studies have anticipated

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[61] City of Toronto, "Electric Vehicles," 2018. https://www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/reports-plans-policies-research/electric-vehicles/

[62] James Winebrake, Erin Green, and Edward Carr, *Plug-In Electric Vehicles: Economic Impacts and Employment Growth* (2017). http://www.caletc.com/wp-content/uploads/2017/11/EERA-PEV-Economic-Impacts-and-Employment-Growth.pdf

[63] Bloomberg New Energy Finance. "Electric Vehicle Outlook 2018 - Overview" (2018). https://about.bnef.com/electric-vehicle-outlook/

[64] *The Economics of Low Carbon Development.*

significant potential employment gains from the operation of EVs and the manufacturing of EV charging station infrastructure in Ontario under the right policy conditions.[65]

Most relevant methods and multipliers in the literature

Our review was limited to benefits from the deployment of electric passenger cars, and did not cover other forms of electric mobility (e.g., scooters and e-bikes) or electric transit buses.

The most relevant methods and multipliers in the literature include an Ontario-based study by the Windfall Centre[66] which modelled economic output and job creation from the manufacturing and operation of EVs and the deployment of EV charging infrastructure. It is beneficial to be able to separate anticipated benefits from manufacturing (which will not accrue in the City of Toronto, and may not be guaranteed in Ontario) from those other sources. It should be noted that this study assumed the implementation of Ontario's former Climate Change Action Plan and the financial incentives for EV purchase included therein. The study estimated that nearly 35,000 jobs could be created in Ontario in a scenario where 10% of the light-duty fleet is electric by 2025.

Looking at the economic benefits to households, a study by GTAA Partners in Project Green estimated maintenance and fuel savings of $1,800-$2,500 annually for electric car owners in the Greater Toronto Area.[67]

A study in the United States[68] estimated the net social benefit of using one EV at US$12,403, taking into account benefits relating to fuel savings, maintenance savings, environmental impacts from reduced greenhouse gas emissions, health impacts from reduced tailpipe emissions, increased national security through reduced reliance on fossil fuel, and economic development. It assumed a 100% renewable energy source and use of the car over 10 years on a 120,000-mile life cycle. Because the scope of benefits

[65] Windfall Centre, *Getting to 80: Meeting Ontario's emission targets: The Economic Impact of Electric Vehicle Adoption in Ontario* (2014). http://www.windfallcentre.ca/drive-electric/docs/studies/GT80-EVAdoptionStudy-SummaryReport.pdf

[66] *Getting to 80: Meeting Ontario's emission targets: The Economic Impact of Electric Vehicle Adoption in Ontario.*

[67] GTAA Partners in Project Green, *Charge Up Ontario* (2017). https://www.partnersinprojectgreen.com/wp-content/uploads/2017/01/PPG_Charge-Up-Ontario_EVSE-Report-UPDATED-MARCH_1_2017.pdf

[68] Ingrid Malmgren, "Quantifying the Societal Benefits of Electric Vehicles," *World Electric Vehicle Journal* 8 (2016). https://doi.org/10.3390/wevj8040996

quantified is wide-ranging, it is difficult to determine the applicability of this U.S.-based analysis to the Toronto context so it is not considered directly relevant to Toronto.

Possible approaches to quantifying socio-economic equity

EV uptake tends to be higher in higher-income areas.[69] Despite attractive payback times, the initial cost of EVs remains higher than conventional vehicles, which has historically been a barrier for lower-income purchasers. In California, increased rebates have been offered to low- and middle-income purchasers to address this gap. However, the price differential between EVs and conventional vehicles is diminishing, and used EVs are becoming more widely available.

Since the City of Toronto's actions focus largely on EV infrastructure, from an equity perspective it is also important to consider the geographic distribution of chargers, in public space and residences. However, retrofitting existing apartment and condominium buildings for EV chargers is particularly challenging.

One option to quantify socio-economic benefit from EVs in Toronto is to measure the number of vehicles and chargers deployed according to neighbourhood (using Wellbeing Toronto indicators to measure socio-economic status), census tract, or NIA and compare socio-economically disadvantaged areas to the whole and/or in social and affordable housing buildings.

The methods and multipliers identified in the literature for electric vehicles are presented in the Appendix in Table 7. A selection of the most relevant methods and multipliers to the City of Toronto is presented in Table 1, Section 5 (Summary).

4.6 Public transit infrastructure and investments

The buildout and operation of public transit contributes to climate action in the city by enabling a mode shift away from single-occupancy vehicle use.

TransformTO measures

Short-term strategies

- Enhance transit service by implementing the approved Transit Network Plan Update and Financial Strategy.

[69] International Council on Clean Transportation, *Update: California's electric vehicle market* (2017). https://www.theicct.org/publications/update-californias-electric-vehicle-market

- Investigate alternative technologies for future bus fleet procurements.

2050 strategies

- Continue to pursue transit-supportive development and explore concepts such as "retrofitting suburbs" to bring about more sustainable land use configurations.
- Pursue more extensive transit investments to support a modal shift.

Types of benefits

For public transit investments, the benefits include:[70,71]

- Direct employment in construction, operation, and maintenance
- Benefits from travel time savings, lower cost of travel and increased accessibility to jobs, education and other activities
    - Socio-economically disadvantaged tend to live in areas with poorer transit service and therefore stand to benefit in particular from these improvements
- Health benefits from reduced pollution and collisions, and increased physical activity
- Land value uplift from transit investments.

A shift to low- or zero-carbon transit fleets can lead to long-term cost savings for transit agencies, who can in turn pass savings back to users in the form of increased service or lower fares.

Benefits can also accrue from operational, rather than capital, improvements to the public transit system. For example, increasing the frequency and reliability of service or reducing or integrating fares could incentivize greater transit use and especially benefit more disadvantaged users in Toronto. Operational investment benefits are not treated in this study.

Most relevant methods and multipliers in the literature

As a form of public infrastructure, transit can have wide-ranging benefits to society. Assessing the contribution of this infrastructure to economic growth is complex and

[70] American Public Transportation Association, *Economic Impact of Public Transportation Investment: 2014 Update* (2014). https://www.apta.com/resources/reportsandpublications/Documents/Economic-Impact-Public-Transportation-Investment-APTA.pdf

[71] AECOM, *Economic Benefits of Major Transportation Investments: An Overview* (2012), 8. http://www.metrolinx.com/en/regionalplanning/funding/Economic_Benefits_of_Major_Transportation_Investments_EN.pdf

requires a knowledge of the local economy, recognizing that there is a spatial component to the analysis.[72] For this reason, many policymakers use cost-benefit analysis to determine how a specific project will affect a local community.

Several Metrolinx business cases are available which present a cost-benefit ratio for a given transit project (shown in Appendix B). Because such ratios are highly project-specific, however, we do not recommend applying cost-benefit ratios from one project to another.

Looking at broader macroeconomic benefits, a study commissioned by Metrolinx[73] reviewed GDP multipliers for public transit investment, and reports multipliers ranging from 1.19 (Conference Board Study) and 1.5 (Centre for Spatial Economics Study) for converting capital and operations spending on public transit to net GDP growth. The study suggests these multipliers could apply to the Metrolinx Investment Strategy between 2012 and 2031. Because Metrolinx' jurisdiction includes the City of Toronto, these multipliers can be considered relevant, with the recognition that the portfolio of projects under Metrolinx' purview is somewhat different from those in Toronto's Transit Network Plan (for example, the Metrolinx network includes GO rail). These multipliers should not be applied to a specific project, but rather to a suite of investments over time.

Studies such as those from the Broadbent Institute[74] and the Centre for Spatial Economics[75] have quantified net GDP or job growth from public infrastructure investment broadly — unfortunately not differentiating benefits from public transit investment. In the latter study, the Ontario government's spending on its ten-year, $140 billion public infrastructure plan that was presented in Budget 2016 was estimated to generate a 4.7 jobs per $1 million spent in the short run, and 17.7 jobs per $1 million

[72] Richard H. Mattoon, "Infrastructure and State Economic Development: A survey of the issues," prepared for Emerging Challenges: New Insights on the Economy and Society, Statistics Canada Economic Conference 2004, Ottawa, Canada, June 7-8, 2004, 11. https://www150.statcan.gc.ca/n1/en/pub/11f0024m/pdf/papers-etudes/4193813-eng.pdf?st=1wn42PpR

[73] *Economic Benefits of Major Transportation Investments*, 3. The report notes that, "one reason which likely accounts for much of the difference is that the Ontario population is exogenous in the Conference Board model, while it is endogenous to the C4SE model (i.e. in the latter model, there is additional net in-migration to Ontario as a direct result of the increased economic activity spurred by the major capital program)" (p. 6).

[74] Broadbent Institute, *The Economic Benefits of Public Infrastructure Spending in Canada* (2015). http://www.broadbentinstitute.ca/infrastructure

[75] Centre for Spatial Economics, The economic benefits of public infrastructure spending in Ontario (2017), 1. http://www.c4se.com/documents/Ontario%20Public%20Infrastructure%20Final%20Report.pdf

spent in the long run. This range is considered the most relevant job multiplier for public transit in the absence of transit-specific job multipliers in the literature.

Possible approaches to quantifying socio-economic equity

The transportation sector, especially public transit, provides an interesting example of how equity can be quantified. Most research on equity in transportation incorporates terms such as transport-related social exclusion, transport disadvantage, and mobility-related exclusion to express the idea that certain groups or areas are more socio-economically disadvantaged, in part because they are underserved by the transportation system.[76] In response, accessibility measures are commonly used[77] to quantify the ease of reaching different opportunities (e.g. employment, education, health services, and social activities) from different trip origins.[78,79] By comparing accessibility levels among different groups and places, policymakers have a more systematic way to identify where investments need to be made in order to close the transportation equity gap. Accessibility measures are therefore a good example of how equity can be incorporated into impact studies. However, such measures are highly context-dependent and do not lead to the development of simple multipliers.

More simply, measuring the geographic distribution of public transit investments can give an indication of whether less well-served neighbourhoods are benefitting from investment. One option to quantify socio-economic benefit from transit in Toronto, therefore, is to measure the number of new kilometres or dollars spent on public transit according to neighbourhood (using Wellbeing Toronto indicators to measure socio-economic status), census tract, or NIA and compare socio-economically disadvantaged areas to the whole.

The methods and multipliers identified in the literature for public transit infrastructure and investments are presented in the Appendix in Table 8. A selection of the most

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[76] Md. Kamruzzaman, Tan Yigitcanlar, Jay Yang, and Mohd Afzan Mohamed, "Measures of transport-related social exclusion: A critical review of the literature," *Sustainability* 8 (2016). doi: 10.3390/su8070696

[77] Karst T. Geurs and Bert van Wee, "Accessibility evaluation of land-use and transport strategies: review and research directions," *Journal of Transport Geography* 12, 2 (2004). doi:10.1016/j.jtrangeo.2003.10.0

[78] Social Exclusion Unit, *Making the Connections: Final report on Transport and Social Exclusion* (Office of the Deputy Prime Minister, London, 2003), 1. http://www.ilo.org/emppolicy/pubs/WCMS_ASIST_8210/lang--en/index.htm

[79] Jason Neudorf, *Understanding accessibility, analyzing policy: New approaches for a new paradigm* (2014). http://hdl.handle.net/10012/8759

relevant methods and multipliers to the City of Toronto is presented in Table 1, Section 5 (Summary).

4.7 Active transportation infrastructure

Expanding cycling and pedestrian infrastructure contributes to climate action in the city by enabling a mode shift away from single-occupancy vehicle use.

TransformTO measures

Short-term strategies

- Support safe cycling and walking by pursuing the Ten Year Cycling Network Plan, approved in principle by City Council in June 2016, alongside the Vision Zero Road Safety Plan, Complete Streets Guidelines, Toronto Walking Strategy, Pedestrian Charter, Missing Links Sidewalks Capital Program, Toronto Senior Strategy, and other strategies to enhance the built environment for active transportation.

2050 strategies

- Continue to implement the Ten Year Cycling Network Plan, which will be updated with an extended outlook every few years to continuously grow the city-wide network, and upgrade facilities to reflect emerging best practices over time.
- Continue to implement the Vision Zero initiatives, Complete Streets Guidelines, Toronto Walking Strategy, Pedestrian Charter, Missing Links Sidewalks Capital Program, and Toronto Senior Strategy.

Types of benefits

The economic and socio-economic equity benefits of active transportation are similar to those of public transit and include:

- Direct employment in construction of sidewalks and cycling infrastructure
- Benefits from increased accessibility to jobs and other activities, and reduced travel time
    - Socio-economically disadvantaged groups benefit in particular from these improvements, in part because they tend to live in areas with unsafe or absent active transportation infrastructure.
- Health benefits from reduced pollution and collisions, increased physical activity, and the resulting increase in productivity

- Increased property values and commercial activity associated with walkable, cycleable environments.

Most relevant methods and multipliers in the literature

In the literature, health benefits tend to feature strongly in economic analyses of active transportation benefits. Several studies link public expenditure on cycling and pedestrian infrastructure (often combined) to net social benefit or GDP.

A study in Southern California[80] found that US$5.20 was added to regional economic activity for each dollar invested in implementing the region's active transportation strategy, including investing in cycling infrastructure and sidewalks. These "value-added" benefits impacts accrue to businesses inside the region largely due local increases in labour productivity. This multiplier is useful because it quantifies benefits that accrue locally; however some caution should be applied when using it in the Canadian context (due to, e.g., seasonal differences and different healthcare systems).

Other studies quantify the net social benefit based on the kilometres travelled by bike or by foot. Studies from Copenhagen[81] and Australia[82] are available with this type of multiplier. These multipliers are not the most relevant for the present study because the City does not have kilometres cycled or walked as a base unit (while this could be obtained from the Transportation Tomorrow Survey, it would not show the change in behavior resulting from *TransformTO*-specific investments).

Unfortunately, the literature review did not reveal methods and multipliers specific to types of cycling infrastructure (e.g., cycle tracks versus multi-purpose trails) or specific to street types (e.g., residential versus commercial). It is therefore important to use the available multipliers for investment as a whole and avoid applying them to specific projects.

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[80] Southern California Association of Governments, *Active Transportation Health and Economic Impact Study,* prepared by Urban Design 4 Health and AECOM (2016). http://www.ochealthiertogether.org/content/sites/ochca/Local_Reports/SCAG_Active_Transportation_Health_and_Economic_Impact_Study_2016.pdf

[81] COWI and City of Copenhagen, *Economic evaluation of cycle projects - methodology and unit prices* (2009). http://www.cycling-embassy.dk/wp-content/uploads/2010/06/COWI_Economic-evaluation-of-cycle-projects.pdf

[82] Corinne Mulley, Rob Tyson, Peter McCue, Chris Rissel, and Cameron Munro, "Valuing active travel: Including the health benefits of sustainable transport in transportation appraisal frameworks," *Research in Transportation Business & Management* 7 (2013). https://www.sciencedirect.com/science/article/pii/S2210539513000023

Possible approaches to quantifying socio-economic equity

Safe cycling and pedestrian environments tend to be least available in Toronto's more disadvantaged neighbourhoods, so measuring the geographic distribution of active transportation infrastructure investments is important.[83] One option to quantify socio-economic benefit from active transportation is to measure the number of new, repaired or upgraded kilometres of sidewalk and cycling infrastructure according to neighbourhood (using Wellbeing Toronto indicators to measure socio-economic status), dissemination area, census tract, or NIA, and compare socio-economically disadvantaged areas to the whole.

The methods and multipliers identified in the literature for active transportation infrastructure are presented in the Appendix in Table 6. A selection of the most relevant methods and multipliers to the City of Toronto is presented in Table 1, Section 5 (Summary).

[83] Trudy Ledsham and Yvonne Verlinden, *Building Bike Culture Beyond Downtown: A guide to suburban community bike hubs* (The Centre for Active Transportation at Clean Air Partnership, 2019), 8. https://www.tcat.ca/wp-content/uploads/2019/01/Building-Bike-Culture-Beyond-Downtown-Report-Web-Version-compressed.pdf

5. Summary

The summary tables in Appendix A present all of the methods and multipliers derived from the systematic search for the Toronto context.

Below, we summarize the most relevant methods and multipliers presented in the sections above. Sources are listed at the end of Appendix A.

Table 1. Summary table of methods and multipliers most relevant to Toronto for all climate actions

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
Buildings								
Building standards								
New commercial and healthcare	Economic	Jobs	United States	a, 3.	Modelling using IMPLAN	Investment (US$ million)	19.2 job-years/US$1 million investment	Job-years
New single- and multi-family structures	Economic	Jobs	United States	a, 3.	Modelling using IMPLAN	Investment (US$ million)	17.1 job-years/US$1 million investment	Job-years
Retrofits								
All	Equity	Distribution				Investment ($ million)	Geographic distribution	Investment ($)/low-income Ward or census tract, NIA
All	Equity	Distribution				#TCHC units retrofitted		#TCHC units retrofitted

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
Commercial	Economic	Jobs	United States	d	Input-output modelling (IMPLAN v3) using Bureau of Economic Analysis data and other sources to compile outcomes across 440 industries	Investment (US$ million)	12.94 jobs/US$1 million investment	Jobs
Commercial	Economic	Jobs	Calgary, AB	e	Modelling	Investment ($ million)	8.7 job-years/$1 million investment	Job-years
Multifamily residential	Economic	Jobs	United States	d	Input-output modelling (IMPLAN v3) using Bureau of Economic Analysis data and other sources to compile outcomes across 440 industries	Investment (US$ million)	13.41 jobs/US$1 million investment	Jobs
Residential	Economic	Jobs	Calgary, AB	e	Modelling	Investment ($ million)	13.1 job-years/$1 million investment	Job-years
Residential and C&I	Economic	Economic output	Ontario	b	Modelling, using Regional Economic Models, Inc. (REMI)	Investment ($)	2.4-3.0	Net GDP ($)
Residential and C&I	Economic	Jobs	Ontario	b	Modelling, using Regional Economic Models, Inc. (REMI)	Investment ($ million)	17-21 job-years/$1 million investment	Job-years
Energy								
Decentralized renewable								
All	Equity	Distribution				MW installed	Geographic distribution	MW installed/low-income Ward or census tract, NIA, or TCHC building

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
All	Equity	Distribution				MW installed on TCHC buildings	Geographic distribution	MW installed on TCHC buildings
Residential solar PV	Economic	Jobs	Ontario	j	Model: JEDI model	MW installed	20.9 job-years/MW	Job-years
Solar PV	Economic	Economic output	Ontario	j	Model: JEDI model	MW installed	$900,000/MW	GDP ($)
Solar PV	Economic	Jobs	Canada	k	Model: JEDI model	MW installed	10.3 job-years/MW	Job-years
District energy								
All	Equity	Distribution				m^2 floor area connected	Geographic distribution	m^2/low-income Ward or census tract, NIA, or TCHC building
Combined heat and power using natural gas	Economic	Economic output	Markham, ON	l	Model using Natural Resources Canada's DEEM	$1 investment	1.37	GDP ($)
Transport								
Active transportation								
All active transportation	Economic	Economic output	Southern California	q, 7.	Model: REMI's Transight	Expenditure on implementing active transportation strategy ($)	5.20	Value added ($)
All active transportation	Equity	Distribution				New km sidewalk and cycling infrastructure	Geographic distribution	New km per Ward/NIA

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
Electric vehicles								
Charging infrastructure	Economic	Economic output	Ontario	r, 86.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($)	1.35	Value added ($)
Charging infrastructure	Economic	Jobs	Ontario	r, 86.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($ million)	16.38 person-years/$ million expenditure	Person-years
Charging infrastructure	Equity	Distribution				Number of chargers	Geographic distribution	Number of chargers per low-income Ward or census tract, NIA
Operation of EVs	Economic	Economic output	Ontario	r, 73.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($)	1.25	Value added ($)
Operation of EVs	Economic	Energy cost savings	Ontario	s, 4.	Model	Number of vehicles	$1,800-2,500/vehicle	Annual maintenance and fuel savings to household ($)
Operation of EVs	Economic	Jobs	Ontario	r, 73.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($ million)	9.13 person-years/$ million expenditure	Person-years
Operation of EVs	Equity	Distribution				Number of vehicles	Geographic distribution	Number of vehicles per low-income Ward or census tract, NIA
Public transit								
All public infrastructure	Economic	Jobs	Ontario	u, 1.	Model: C4SE's provincial economic modeling system	Provincial spending on public infrastructure ($ million)	4.7-17.7	Jobs

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
All transit	Economic	Economic output	Ontario	t, 6.	Model	Capital and O&M spending ($)	1.19-1.5	Net GDP ($)
All transit	Equity	Distribution				Investment ($)	Geographic distribution	$1 investment per Ward/NIA
All transit	Equity	Distribution				New build (km)	Geographic distribution	New km per Ward/NIA

6. Conclusion

This report has summarized from a systematic literature review available methods and multipliers for quantifying economic and socio-economic equity benefits of climate action in cities. It is clear that significant benefits beyond GHG emissions reductions are possible for the City of Toronto as it implements *TransformTO,* an ambitious climate action strategy. This work is a first step in quantifying those potential benefits, guiding investment decisions to maximize benefit, and ultimately measuring the benefits associated with program results and adjusting as necessary.

It is important to note that methods and multipliers derived from the literature, especially from other jurisdictions, should be applied and interpreted with caution in the Toronto context. For example, caution is required when applying multipliers derived from macroeconomic analysis to a specific project. Further, the literature review approach contains some inherent limitations related to matching the local conditions, time and duration of intervention, labour markets and other characteristics from studies to Toronto's climate plan. While our review prioritizes conservative estimates recently drawn from jurisdictions whose economic characteristics resemble those of the City of Toronto, there is no replacement for modelling based on local conditions and using results of program measurement as the actions are rolled out.

Nonetheless, these findings start the important work of understanding and communicating the multiple benefits from climate action in Toronto. The City of Toronto has an opportunity to share lessons learned from this exercise with leaders in other cities across Canada.

Appendix A. Methods and multipliers

The summary tables below present all of the methods and multipliers derived from the systematic search for the Toronto context. Sources are listed at the end of this appendix.

See Table 1 in the report body for a summary of the methods and multipliers most relevant to Toronto.

Table 2. Methods and multipliers for benefits from green building standards

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
--	Economic	Other	Los Angeles, CA	g	Program evaluation	Rent/sqft (status quo) ($)	125-135%	Rent/sqft for green buildings ($)
--	Economic	Other	Los Angeles, CA	g	Program evaluation	Asking price/sqft (status quo) ($)	141-235%	Sales price/sqft for green buildings ($)
LEED-certified buildings	Economic	Energy cost savings	United States	a, 3.	Modelling using IMPLAN	Floor area (sqft)	US$0.91/sqft	Annual savings ($)
New commercial and healthcare	Economic	Jobs	United States	a, 3.	Modelling using IMPLAN	Investment (US$ million)	19.2 job-years/US$1 million investment	Job-years
New Green Building	Economic	Energy cost savings	Canada	f, 7.	Survey of green building owners	Operating costs (status quo) ($)	8%	Decrease in operating costs over one year for green building
New Green Building	Economic	Energy cost savings	Canada	f, 7.	Survey of green building owners	Operating costs (status quo) ($)	11%	Decrease in operating costs over five years for green building
New Green Building	Economic	Other	Canada	f, 7.	Survey of green building owners and architects	Value of building (status quo) ($)	4%	Increase in building value of green building

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
New single- and multi-family structures	Economic	Jobs	United States	a, 3.	Modelling using IMPLAN	Investment (US$ million)	17.1 job-years/US$1 million investment	Job-years
Retrofits and building standards								
All	Economic	Jobs	United States	d	Input-output modelling (IMPLAN v3) using Bureau of Economic Analysis data and other sources to compile outcomes across 440 industries	Energy cost savings (US$1 million)	5.32 jobs/US$1 million energy cost savings	Jobs
All	Economic	Economic output	Canada	i	Modelling, using C4SE macroeconomic model	Government investment ($)	4.0-7.0	Net GDP ($)
All	Economic	Jobs	Canada	i	Modelling, using C4SE macroeconomic model	Government investment ($ million)	16-30 job-years/$1 million government investment	Job-years

Table 3. Methods and multipliers for benefits from building retrofits

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
All	Equity	Distributi on				Investment ($)	Geographic distribution	Investment ($)/low-income Ward or census tract, NIA
All	Equity	Distributi on				#TCHC units retrofitted		#TCHC units retrofitted

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
Commercial	Economic	Jobs	United States	d	Input-output modelling (IMPLAN v3) using Bureau of Economic Analysis data and other sources to compile outcomes across 440 industries	Investment (US$ million)	12.94 jobs/US$1 million investment	Jobs
Commercial	Economic	Jobs	Calgary, AB	e	Modelling	Investment ($ million)	8.7 job-years/$1 million investment	Job-years
Homes	Economic	Energy savings	Toronto, ON		Program evaluation	Number of homes retrofitted	Energy savings per unit	
Multifamily residential	Economic	Jobs	United States	c	Input-output modelling (IMPLAN v3) using Bureau of Economic Analysis data and other sources to compile outcomes across 440 industries	Investment (US$ million)	13.41 jobs/US$1 million investment	Jobs
Residential	Economic	Jobs	Toronto, ON	h	Program evaluation	Government investment ($ million)	7 jobs/$1 million government investment	Jobs
Residential	Economic	Jobs	Calgary, AB	e	Modelling	Investment ($ million)	13.1 job-years/$1 million investment	Job-years
Residential and C&I	Economic	Economic output	Ontario	b	Modelling, using Regional Economic Models, Inc. (REMI)	Investment ($)	2.4-3.0	Net GDP ($)
Residential and C&I	Economic	Jobs	Ontario	b	Modelling, using Regional Economic Models, Inc. (REMI)	Investment ($ million)	17-21 job-years/$1 million investment	Job-years

Applies to	Benefit category	Benefit type	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
Residents, businesses, city government	Economic, equity	Energy cost savings	Chicago, IL	c	Program evaluation	Government investment ($ million)	$225,000/$1 million government investment	Society-wide cost savings ($)
Retrofits and building standards								
All	Economic	Jobs	United States	d	Input-output modelling (IMPLAN v3) using Bureau of Economic Analysis data and other sources to compile outcomes across 440 industries	Energy cost savings (US$1 million)	5.32 jobs/US$1 million energy cost savings	Jobs
All	Economic	Economic output	Canada	i	Modelling, using C4SE macroeconomic model	Government investment ($)	4.0-7.0	Net GDP ($)
All	Economic	Jobs	Canada	i	Modelling, using C4SE macroeconomic model	Government investment ($ million)	16-30 job-years/$1 million government investment	Job-years

Table 4. Methods and multipliers for benefits from decentralized renewable energy

Applies to	Benefit category	Benefit type2	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
All	Equity	Distribution				MW installed	Geographic distribution	MW installed/low-income Ward or census tract, NIA, or TCHC building
All	Equity	Distribution				MW installed on TCHC buildings		MW installed on TCHC buildings
Commercial solar PV	Economic	Jobs	Ontario	e	Custom model	Investment ($ million)	9.2	Job-years

Applies to	Benefit category	Benefit type2	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
PV on social and affordable housing	Economic, equity	Jobs	Ontario	p	Measurement of program outcomes plus estimations	Investment ($ million)	10.5 jobs/$1 million investment	Jobs
PV on social and affordable housing	Economic, equity	Other	Ontario	p	Measurement of program outcomes plus estimations	Investment ($)	1.6	Net benefits for housing providers ($)
Residential solar PV	Economic	Jobs	Ontario	j	Model: JEDI model	MW installed	20.9 job-years/MW	Job-years
Residential solar PV (existing homes)	Economic	Jobs	Ontario	e	Custom model	Investment ($ million)	8.8	Job-years
Residential solar PV (new homes)	Economic	Jobs	Ontario	e	Custom model	Investment ($ million)	9.1	Job-years
Solar PV	Economic	Economic output	Ontario	j	Model: JEDI model	MW installed	$900,000/MW	GDP ($)
Solar PV	Economic	Jobs	Canada	k	Model: JEDI model	MW installed	10.3 job-years/MW	Job-years
Solar PV	Economic	Jobs	Canada	o	Model: JEDI model	MW installed	12.5 jobs/MW	Jobs

Table 5. Methods and multipliers for benefits from district energy system installations

Applies to	Benefit category	Benefit type2	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
All	Equity	Distribution				Number of social and affordable housing units connected		Number of social and affordable housing units connected
All	Economic	Jobs	Canada	n	Unknown	MW system	7.4 jobs/MW	Jobs

Applies to	Benefit category	Benefit type2	Jurisdiction	Source study	Method used in study	Base unit	Multiplier	Benefit unit
Biomass system	Economic	Jobs	Courtenay, B.C.	m	Model	Investment ($ million)	2.5 job-years/$ million investment	Job-years
Combined heat and power using natural gas	Economic	Economic output	Markham, ON	l	Model using Natural Resources Canada's DEEM	$1 investment	1.37	GDP ($)

Table 6. Methods and multipliers for benefits from active transportation infrastructure

Applies to	Benefit category	Benefit type	Jurisdiction	Source	Model or Measurement	Base unit	Multiplier	Benefit unit
All active transportation	Economic	Economic output	Southern California	q, 7.	Model: REMI's Transight	Expenditure on implementing active transportation strategy ($)	5.20	Value added ($)
All active transportation	Equity	Distributio n				New km sidewalk and cycling infrastructure	Geographic distribution	New km per Ward/NIA
All active transportation	Economic	Economic output	Southern California	q, 7.	Model: REMI's Transight	Expenditure on implementing active transportation strategy ($)	8.41	Sales output ($)
Cycling	Economic	Health	Australia	v, 27.	Model	Distance cycled (km)	$1.12/km	Benefit in reduced mortality and morbidity ($)
Cycling	Economic	Other	Copenhagen, DK	w, 10.	Measured	Distance cycled annually for work/school commuting (km)	1.22 DKK ($0.25 CAD)/km	Benefit ($)

Applies to	Benefit category	Benefit type	Jurisdiction	Source	Model or Measurement	Base unit	Multiplier	Benefit unit
Cycling	Economic	Other	England	x, 5.	Measured	Investment into Cycling Demonstration Towns ($)	2.6-3.5	Benefit ($)
Cycling	Economic	Other	England	y, 38.	--	Investment into "smarter travel choices" ($)	10	Benefit in congestion relief ($)
Walking	Economic	Health	Australia	v, 27.	Model	Distance walked (km)	$1.68/km	Benefit in reduced mortality and morbidity ($)

Table 7. Methods and multipliers for benefits from electric vehicles

Applies to	Benefit category	Benefit type	Jurisdiction	Source	Model or Measurement	Base unit	Multiplier	Benefit unit
Charging infrastructure	Economic	Economic output	Ontario	r, 86.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($)	1.35	Value added ($)
Charging infrastructure	Economic	Jobs	Ontario	r, 86.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($ million)	16.38	Person-years
Charging infrastructure	Equity	Distributio n				Number of chargers	Geographic distribution	Number of chargers per low-income Ward or census tract, NIA
Charging infrastructure	Economic	Other	Ontario	s, 86.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($)	0.41	Tax revenue ($)
Manufacturing of EVs	Economic	Economic output	Ontario	s, 60.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($)	1.07	Value added ($)

Applies to	Benefit category	Benefit type	Jurisdiction	Source	Model or Measurement	Base unit	Multiplier	Benefit unit
Manufacturing of EVs	Economic	Other	Ontario	s, 60.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($)	0.32	Tax revenue ($)
Manufacturing of EVs	Economic	Jobs	Ontario	s, 60.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($ million)	11.12 person-years/$ million expenditure	Person-years
Operation of EVs	Economic	Economic output	Ontario	r, 73.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($)	1.25	Value added ($)
Operation of EVs	Economic	Energy cost savings	Ontario	s, 4.	Model	Number of vehicles	$1,800-2,500/vehicle	Annual maintenance and fuel savings to household ($)
Operation of EVs	Economic	Jobs	Ontario	r, 73.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($ million)	9.13 person-years/$ million expenditure	Person-years
Operation of EVs	Equity	Distributio n				Number of vehicles	Geographic distribution	Number of vehicles per low-income Ward or census tract, NIA
Operation of EVs	Economic	Energy cost savings	Florida, USA	z, 13.	Model	Number of vehicles	$1,700/vehicle	Annual maintenance and fuel savings to household ($)
Operation of EVs	Economic	Other	Ontario	s, 73.	Model: Regional Impact Model (RIM) by Econometric Research	Initial expenditure ($)	0.36	Tax revenue ($)
Operation of EVs	Economic, health	Other	United States	aa	Model	Number of vehicles	$12,403	Net social benefit ($)

Table 8. Methods and multipliers for benefits from public transit infrastructure and investments

Applies to	Benefit category	Benefit type	Jurisdiction	Source	Model or Measurement	Base unit	Multiplier	Benefit unit
All public infrastructure	Economic	Jobs	Ontario	u, 1.	Model: C4SE's provincial economic modeling system	Provincial spending on public infrastructure ($ million)	4.7-17.7	Jobs
All public infrastructure	Economic	Economic output	Ontario	u, 1.	Model: C4SE's provincial economic modeling system	Provincial spending on public infrastructure ($)	0.91-5.98	Net GDP ($)
All public infrastructure	Economic	Jobs	Ontario	u, 28.	Model: C4SE's provincial economic modeling system	Provincial and federal spending on public infrastructure ($ million)	7.6	Jobs
All transit	Economic	Economic output	Ontario	t, 6.	Model	Capital and O&M spending ($)	1.19-1.5	Net GDP ($)
All transit	Equity	Distributio n				Investment ($)	Geographic distribution	$1 investment per Ward/NIA
All transit	Equity	Distributio n				New build (km)	Geographic distribution	New km per Ward/NIA
BRT	Economic	Other	N/A (illustrative example)	cc, 12.	Model	Capital and O&M spending ($)	0.6-1.1	Benefit ($)
LRT	Economic	Other	Ontario	bb, 36.	Model	Investment ($)	1.01	Benefit ($)
Rail	Economic	Other	Ontario	dd, xix.	Model	Investment ($)	2.6	Benefit ($)
Rail (electrification)	Economic	Other	Ontario	ee, 56.	Model	Investment ($)	0.36 -1.11	Benefit ($)

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